- ADD 405980

HEXCEL® PRODUCTS INC.
World leader in honeycomb

PLASTEC COPY
PLASTEC Ref. 533
ADL Ref. 331

Number	TSB-101
Date	4/28/59
Page	1
Supersedes of 9/25/58	TR-24

19960424 041

TECHNICAL SERVICE BULLETIN

PROPERTIES OF HEXCEL HEAT RESISTANT REINFORCED PLASTIC HONEYCOMB

INTRODUCTION

In recent years, significant improvements in the heat resistance of plastics have been achieved. An investigation of these materials combined with new concepts of honeycomb construction has resulted in several new honeycomb products with improved mechanical properties.

PURPOSE

To summarize the mechanical properties of Hexcel heat resistant reinforced plastic honeycomb.

MATERIALS

All the honeycomb types evaluated were manufactured on production equipment. Most of them are standard production materials and any honeycomb considered as experimental is identified by the Prefix "X" in the designation. The following table provides a description of these materials.

PLASTEC 0533

DISTRIBUTION STATEMENT A
Approved for public release
Distribution Unlimited

DEPARTMENT OF DEFENSE
PLASTICS TECHNICAL EVALUATION CENTER
PICATINNY ARSENAL, DOVER, N. J.

UNCLASSIFIED/UNLIMITED

UNCLASSIFIED/UNLIMITED

HEXCEL HEAT RESISTANT REINFORCED PLASTIC HONEYCOMB

DESIGNATION	DESCRIPTION	NOMINAL DENSITIES PCF
CTL 3/16 GF	Standard CTL Phenolic Honeycomb with 3/16 inch cell size and 112 Glass Fabric Reinforcement.	5.5, 7.0, 9.0, 10.0
HRL 3/16 GF	Improved Heat Resistant Phenolic Honeycomb with 3/16 inch cell size and Glass Fabric Reinforcement.	5.5, 7.0, 9.0, 10.0
HRP 3/16 GF	New Heat Resistant Phenolic Honeycomb with 3/16 inch cell size and Glass Fabric Reinforcement.	5.5, 7.0, 9.0
XHRP 3/16 ASB	Experimental Heat Resistant Phenolic Honeycomb with 3/16 inch cell size and Asbestos Reinforcement	7.0, 9.0
XHRS 3/16 GF	Experimental Heat Resistant Silicone Honeycomb with 3/16 inch cell size and Glass Fabric Reinforcement.	9.0
XHRS 3/16 ASB	Experimental Heat Resistant Silicone Honeycomb with 3/16 inch cell size and Asbestos Reinforcement.	9.0

TEST METHODS

The tests performed on each product have differed slightly (because of specific application evaluation) and therefore testing variables have been introduced. The information as presented here is intended to indicate average properties and allowance for the testing variables have been made to provide comparative information on these materials.

All tests were performed in Hexcel's Research Laboratory on a Tinius Olsen 60,000 pound Universal Testing Machine. All deflections were measured with a differential transformer and load-deflection data were autographically recorded.

For elevated temperature shear tests a forced circulation electric oven was placed in the testing machine, enclosing the test specimen and testing jigs. Test temperature was measured by a thermocouple embedded in the specimen.

Elevated temperature compression tests were accomplished by the use of electrically heated platens; one placed on the table of the test machine and the other attached to suspended, self-aligning compression head. All compression specimens measured 2" x 2" x 1/2" T or 3" x 3" x 5/8" T and were tested bare or with facings or edge stabilized without facings to eliminate edge failures prevalent with bare specimens. The loading rate was adjusted to cause failure after 3-6 minutes of loading.

Shear properties were determined by flexure or plate shear tests. All flexure specimens measured 3" x 8" and were tested as simply supported beams over a 6" span. All facings were Alclad 2024-T3 aluminum. Facing thickness ranged from 0.040 to 0.091 inch, depending on core density, to insure failure of core before skin failure. The load was applied at mid-span, either through one 3/4" x 3" pad or two 5/8" pads placed on 1" centers. The loading rates were within ± 25% of 0.015" per minute mid-span deflection.

The plate shear specimens measured 2" x 5.67" x 0.5" and the tests were performed in tensile shear in accordance with specification MIL Std 401. Since the bulk of shear data was obtained from flexures, plate shear data was adjusted for use only in confirming curve trends.

Aerobond 422 Supported Film Adhesive of 20 mil thickness was used for all core-to-facing bonds, plate shear bonds, and for stabilizing compressive specimen edges.

RESULTS

All results are provided in the form of curves. Compressive strengths at room temperature will be found in Figure 1 and elevated temperature compressive properties in Figure 2. Shear strengths at room temperature are shown in Figures 3 and 4, and at elevated temperature in Figures 5 and 6. Shear modulus at room temperature is to be found in Fugures 7 and 8, and

elevated temperature is to be found in Figures 9 and 10. The effect of elevated temperature on compressive strength is indicated in Figure 11, while its effect on shear strength and shear modulus are shown on Figures 12 and 13 respectively. Figure 14 shows the retention of compressive strengths at elevated temperatures for long periods of exposure.

DISCUSSION

The test data obtained on these materials ranged approximately ± 10% from the average values. Therefore, a plot of these values versus density or temperature describes a band or envelope. The curves as presented here represent the smooth curve best approximating the average of the envelope. The "Points" on the curves represent the nominal densities of the standard products; actual densities may vary ± 10% from the nominal.

At least three specimens were tested for each point shown and for some points as many as 50 specimens were tested. The majority of the points represent tests of six specimens each.

[A 3/16" cell size honeycomb will measure 3/16" across the flats of the hexagonal cell. If a honeycomb is under-expanded this measurement will be less than the nominal 3/16", and if it is over-expanded it will be greater. The effect of under-expansion on shear properties is to increase the strong direction properties and decrease those in the weak direction.] This can be observed in the plots of HRP-3/16-GF Honeycomb. To provide an indication of properties which can be expected from this product with standard expansion, the test values have been adjusted as indicated by the broken curves in Figures 3 through 10. These adjusted values also provide a better comparison of the HRP product with the other honeycomb materials. Thus HRP-3/16-GF, shown in Figures 12, 13, and 14, are adjusted to nominal expansion.

Estimated properties of XHRP-3/16-ASB (Est.) material shown in the curves at 260° F were interpolated between data from tests run at room temperature and 500° F. Except for Figures 3 and 4 showing shear strength of 7.0 XHRP-3/16-ASB at room temperature, there was no reliable data on 5.5 and 7.0 PCF asbestos material to be included in this report. Hence, Figures 1, 2, 5, 6, 7, 8, 9, and 10 show XHRP-3/16-ASB only at 9.0 PCF.

Other than at 9.0 PCF, there is no reliable data for CTL shear modulus at 260° F available, therefore, this is the only density of CTL shown in Figures 9 and 10.

Tests on HRL-3/16-GF were run only at room temperature and 260° F. For this reason Figures 11, 12, and 13 show compressive and shear properties of HRL only up to 260° F.

HRP-3/16-GF honeycomb of 9.0 PCF density is of a different construction than those of lower densities. Because of this, its shear strength and shear modulus are generally much higher than HRP material of lower densities as indicated by the discontinuous curves for HRP in Figures 5 through 10.

CONCLUSIONS

1. In shear strength and shear modulus HRP is generally superior to HRL, and HRL is superior to CTL.

2. The degree of superiority of HRP over HRL in shear strength increases with increasing density.

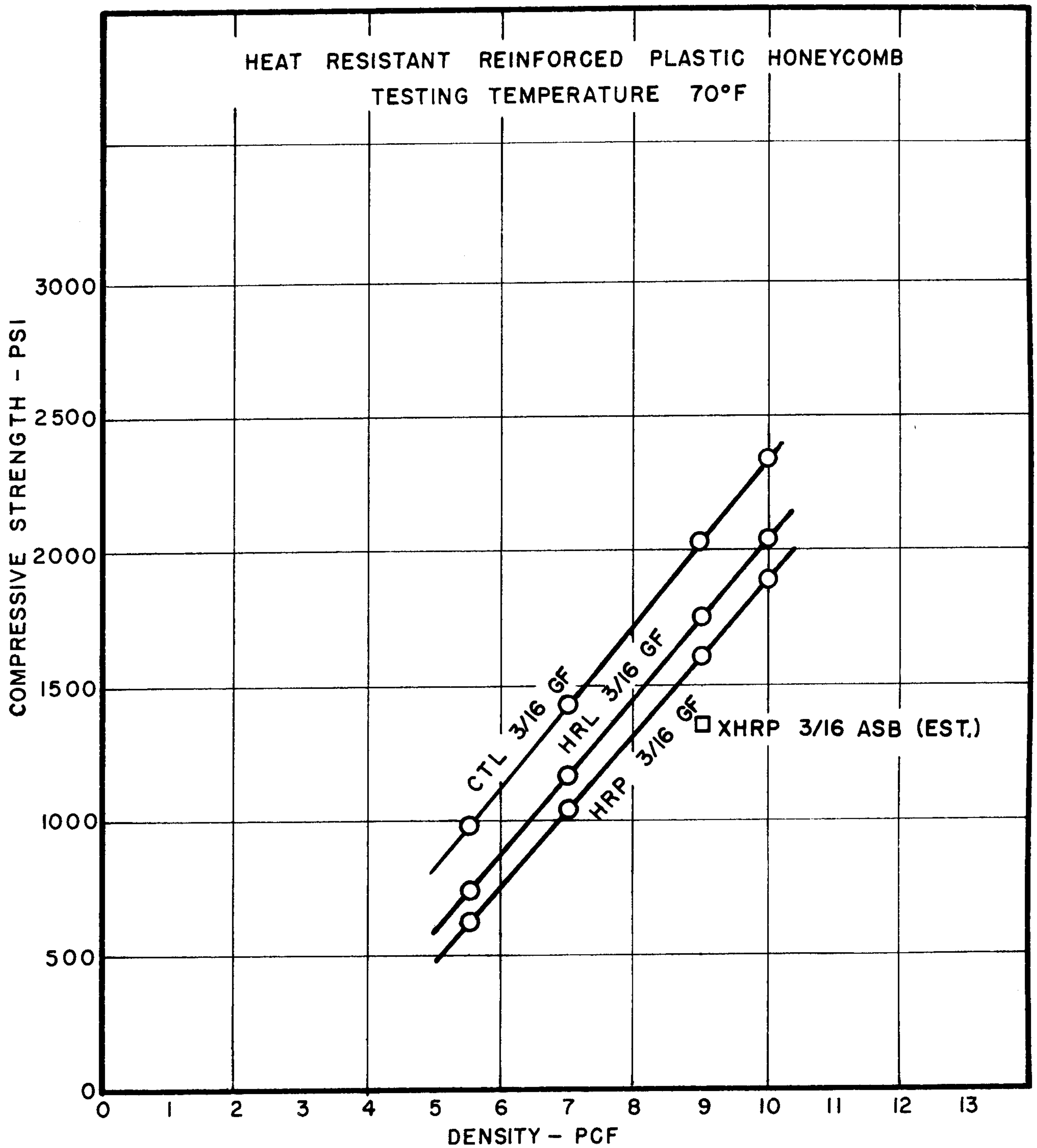
3. HRP is from 10% to 60% superior to CTL in shear properties, increasing with increase in density.

4. At a nine pound density the superiority of HRP in shear strength and modulus over HRL and CTL increases with increasing temperature.

5. CTL is superior to HRP in compressive strength.

6. Silicone honeycomb (XHRS-ASB and XHRS-GF) has relatively low strength but almost no loss of strength occurs as temperature increases from 500° F to 800° F.

7. After one-half hour exposure at high temperature, continued exposure of 192 hours has little or no effect on the high temperature strength of CTL-3/16-GF-9.0 and HRP-3/16-GF-9.0 at 300° F, and HRS-3/16-ASB-9.0 and HRS-3/16-GF-9.0 at 500° F. At 800° F, HRS-3/16-ASB-9.0 retains its high temperature strength to 192 hours while HRS-3/16-GF-9.0 resumes strength deterioration after 96 hours.



HEAT RESISTANT REINFORCED PLASTIC HONEYCOMB
TESTING TEMPERATURE 70°F
COMPRESSIVE STRENGTH - PSI
3000
2500
2000
1500
1000
500
0
0
1
2
3
4
5
6
7
8
9
10
11
12
13
DENSITY - PCF
CTL 3/16 GF
HRL 3/16 GF
HRP 3/16 GF
XHRP 3/16 ASB (EST.)

FIG. 1

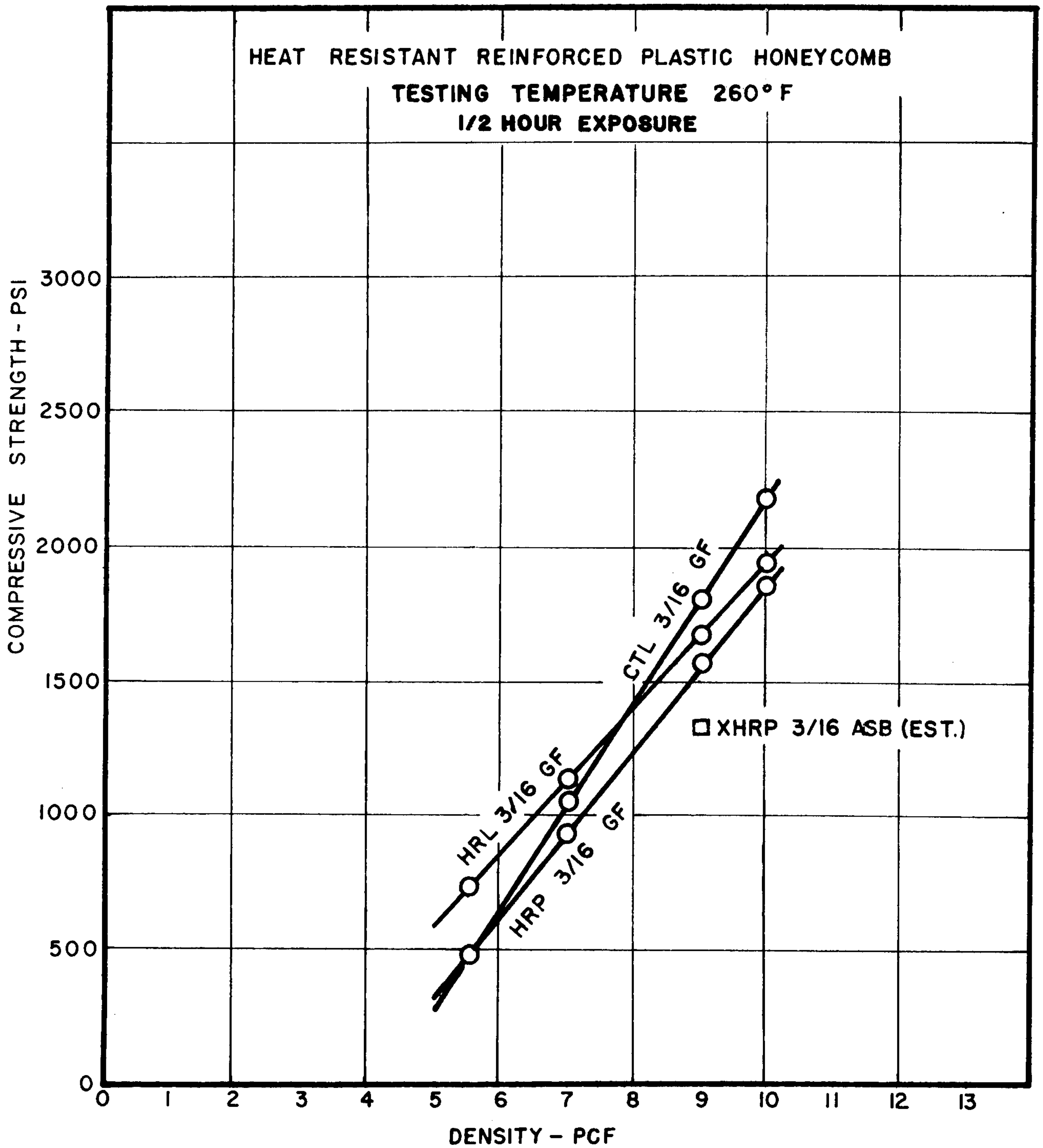

HEAT RESISTANT REINFORCED PLASTIC HONEYCOMB
TESTING TEMPERATURE 260° F
1/2 HOUR EXPOSURE
CTL 3/16 GF
HRL 3/16 GF
HRP 3/16 GF
XHRP 3/16 ASB (EST.)
COMPRESSIVE STRENGTH - PSI
3000
2500
2000
1500
1000
500
0
0
1
2
3
4
5
6
7
8
9
10
11
12
13
DENSITY - PCF

FIG. 2

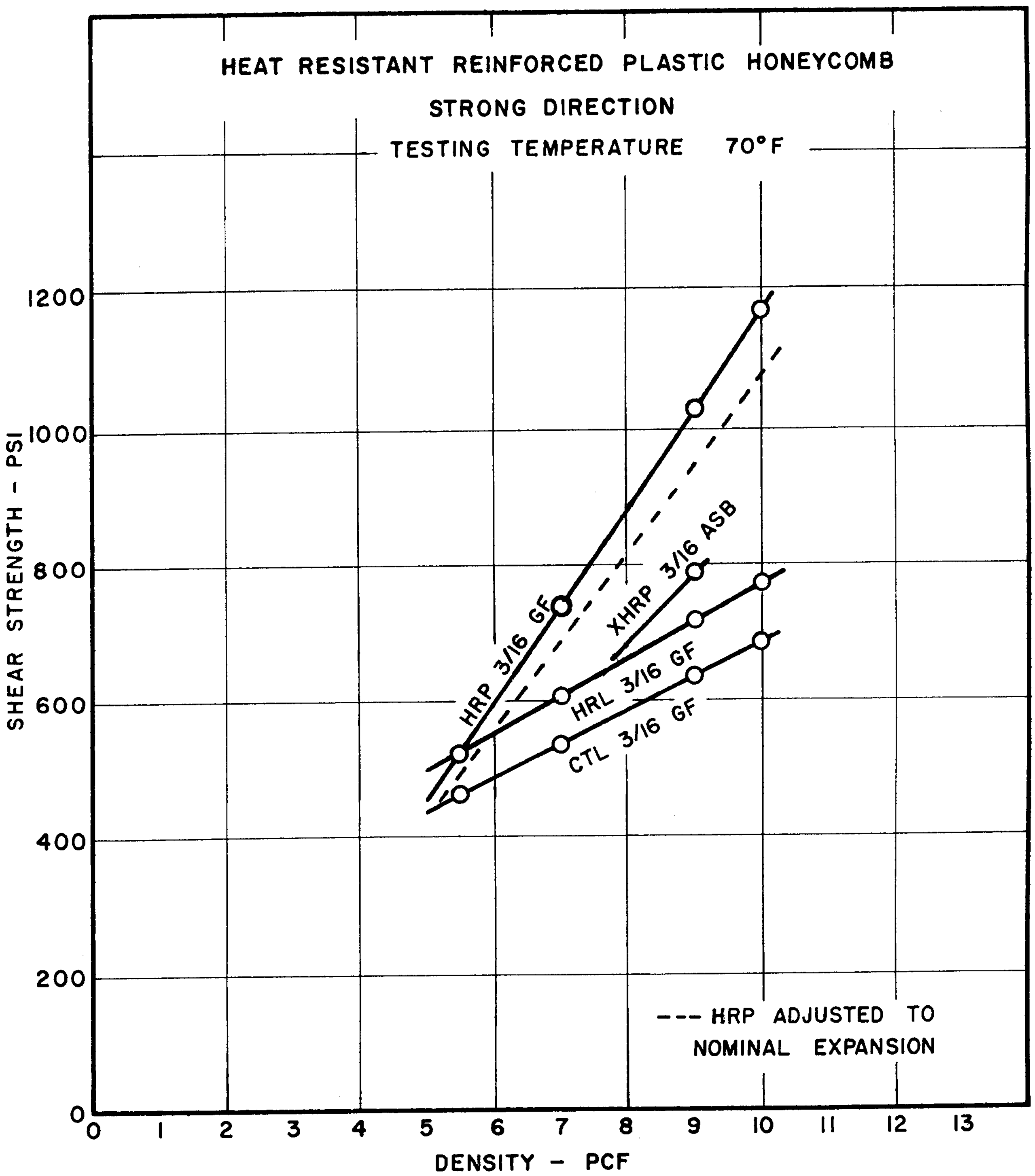
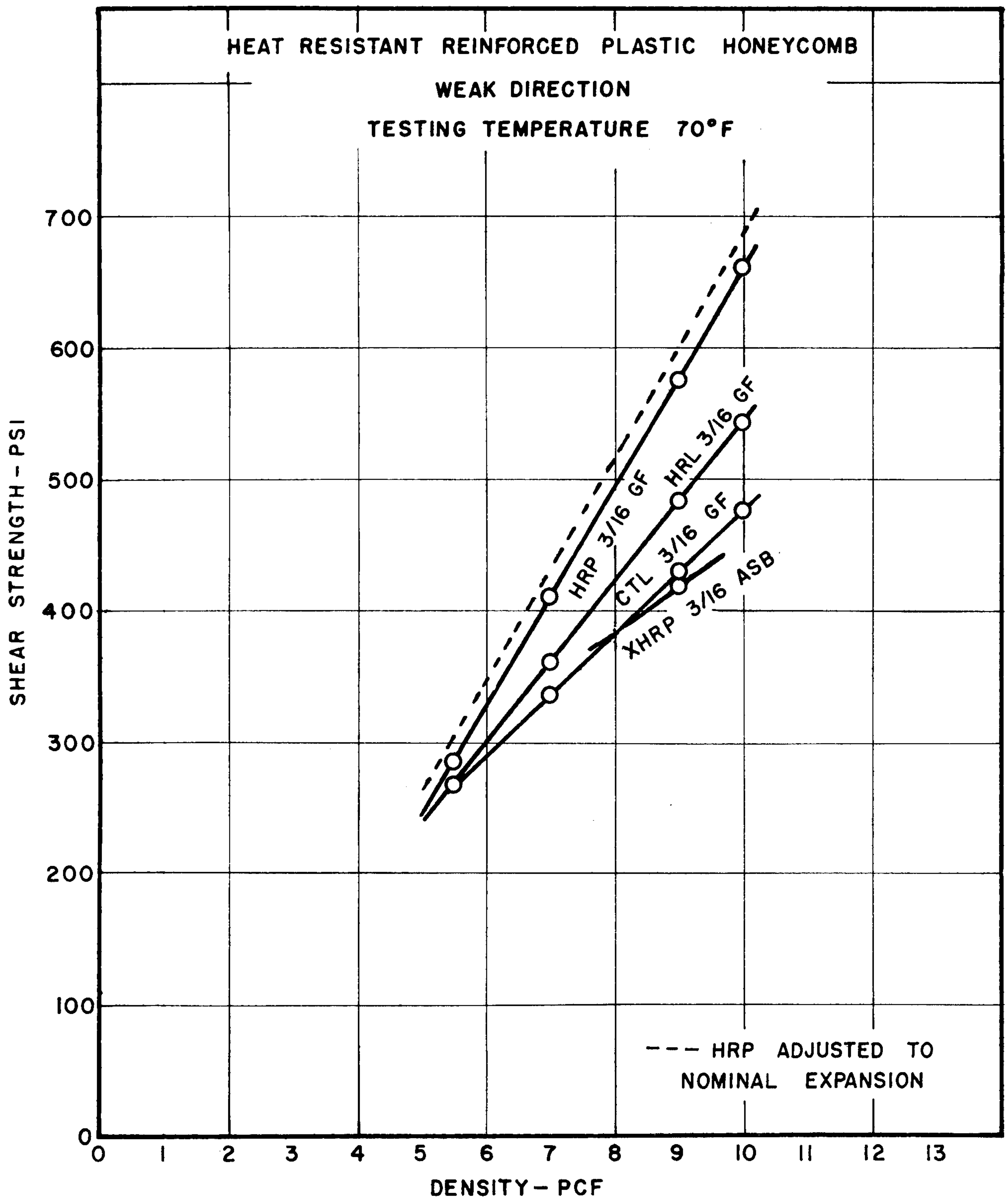

HEAT RESISTANT REINFORCED PLASTIC HONEYCOMB
STRONG DIRECTION
TESTING TEMPERATURE 70°F
SHEAR STRENGTH - PSI
1200
1000
800
600
400
200
0
HRP 3/16 GF
XHRP 3/16 ASB
HRL 3/16 GF
CTL 3/16 GF
--- HRP ADJUSTED TO NOMINAL EXPANSION
0
1
2
3
4
5
6
7
8
9
10
11
12
13
DENSITY - PCF

FIG. 3



HEAT RESISTANT REINFORCED PLASTIC HONEYCOMB
WEAK DIRECTION
TESTING TEMPERATURE 70°F
SHEAR STRENGTH - PSI
700
600
500
400
300
200
100
0
0
1
2
3
4
5
6
7
8
9
10
11
12
13
DENSITY - PCF
HRP 3/16 GF
HRL 3/16 GF
CTL 3/16 GF
XHRP 3/16 ASB
--- HRP ADJUSTED TO NOMINAL EXPANSION

FIG. 4

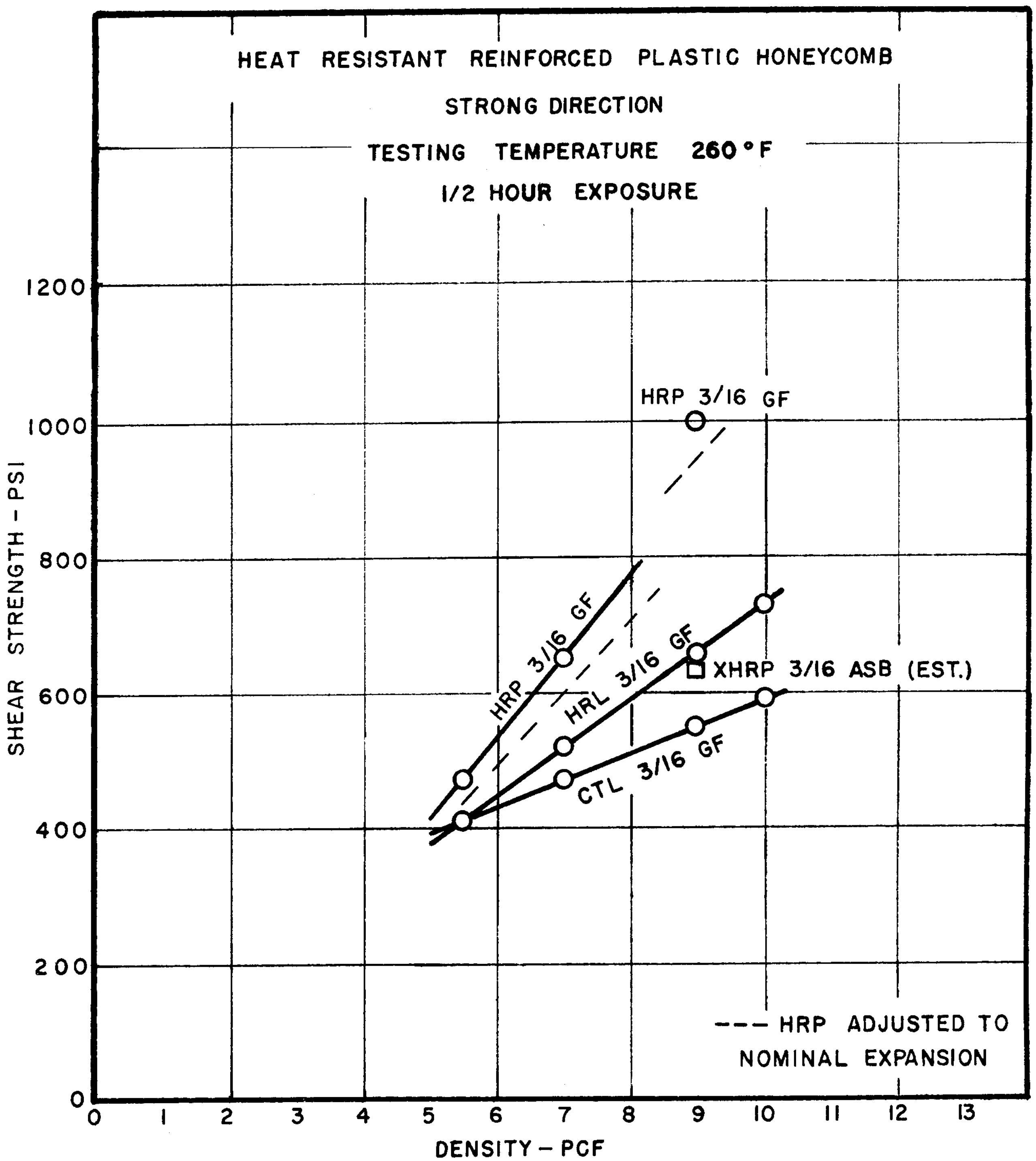

HEAT RESISTANT REINFORCED PLASTIC HONEYCOMB
STRONG DIRECTION
TESTING TEMPERATURE 260 °F
1/2 HOUR EXPOSURE
HRP 3/16 GF
HRP 3/16 GF
HRL 3/16 GF
XHRP 3/16 ASB (EST.)
CTL 3/16 GF
--- HRP ADJUSTED TO NOMINAL EXPANSION
SHEAR STRENGTH - PSI
DENSITY - PCF
0
200
400
600
800
1000
1200
0 1 2 3 4 5 6 7 8 9 10 11 12 13

FIG. 5

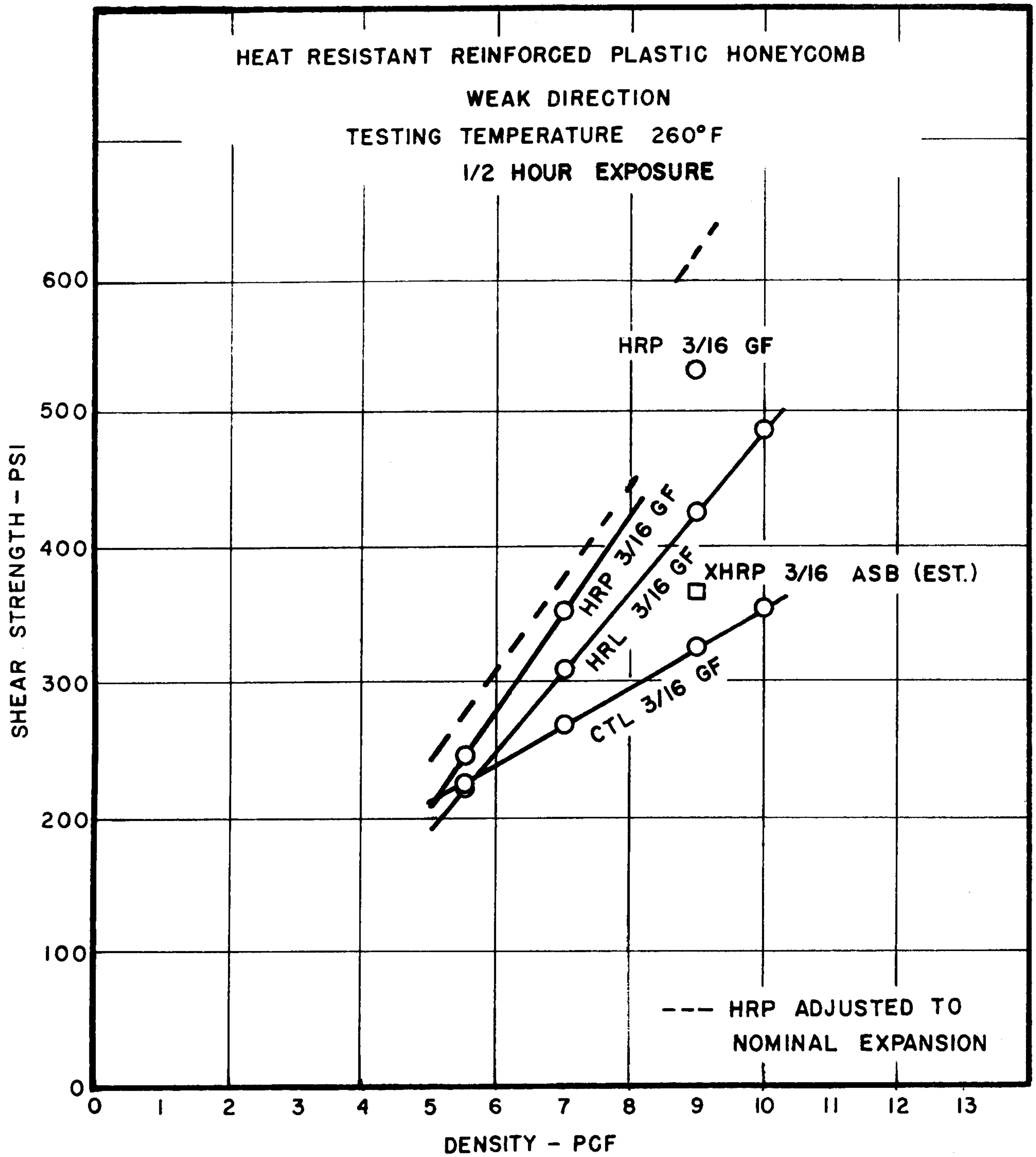

HEAT RESISTANT REINFORCED PLASTIC HONEYCOMB
WEAK DIRECTION
TESTING TEMPERATURE 260°F
1/2 HOUR EXPOSURE
HRP 3/16 GF
HRP 3/16 GF
HRL 3/16 GF
XHRP 3/16 ASB (EST.)
CTL 3/16 GF
--- HRP ADJUSTED TO NOMINAL EXPANSION
SHEAR STRENGTH - PSI
600
500
400
300
200
100
0
0
1
2
3
4
5
6
7
8
9
10
11
12
13
DENSITY - PCF

FIG. 6

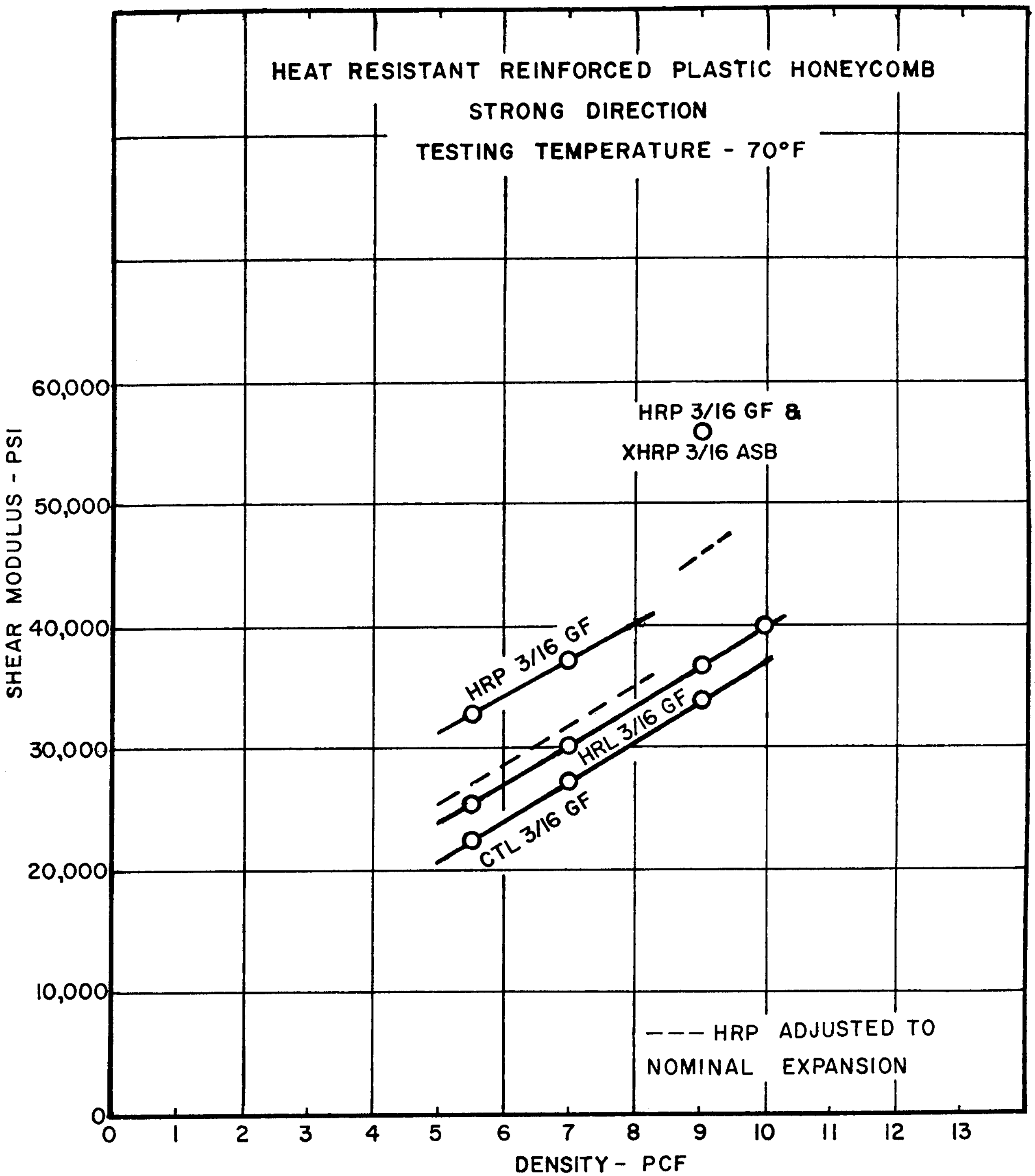
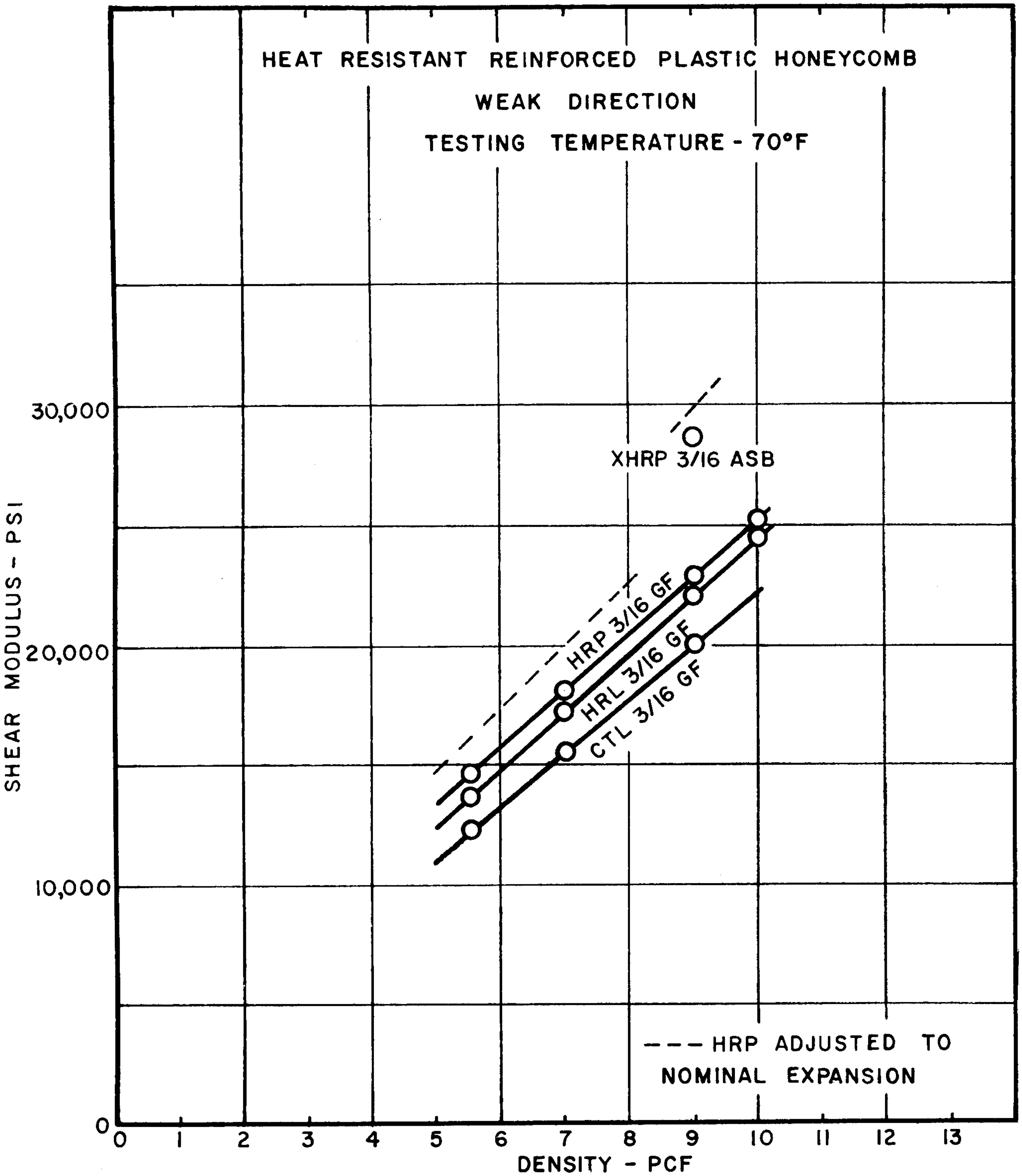

HEAT RESISTANT REINFORCED PLASTIC HONEYCOMB
STRONG DIRECTION
TESTING TEMPERATURE - 70°F
HRP 3/16 GF &
XHRP 3/16 ASB
HRP 3/16 GF
HRL 3/16 GF
CTL 3/16 GF
--- HRP ADJUSTED TO NOMINAL EXPANSION
SHEAR MODULUS - PSI
60,000
50,000
40,000
30,000
20,000
10,000
0
0
1
2
3
4
5
6
7
8
9
10
11
12
13
DENSITY - PCF

FIG. 7



HEAT RESISTANT REINFORCED PLASTIC HONEYCOMB
WEAK DIRECTION
TESTING TEMPERATURE - 70°F
SHEAR MODULUS - PSI
30,000
20,000
10,000
0
XHRP 3/16 ASB
HRP 3/16 GF
HRL 3/16 GF
CTL 3/16 GF
--- HRP ADJUSTED TO NOMINAL EXPANSION
0
1
2
3
4
5
6
7
8
9
10
11
12
13
DENSITY - PCF

FIG. 8

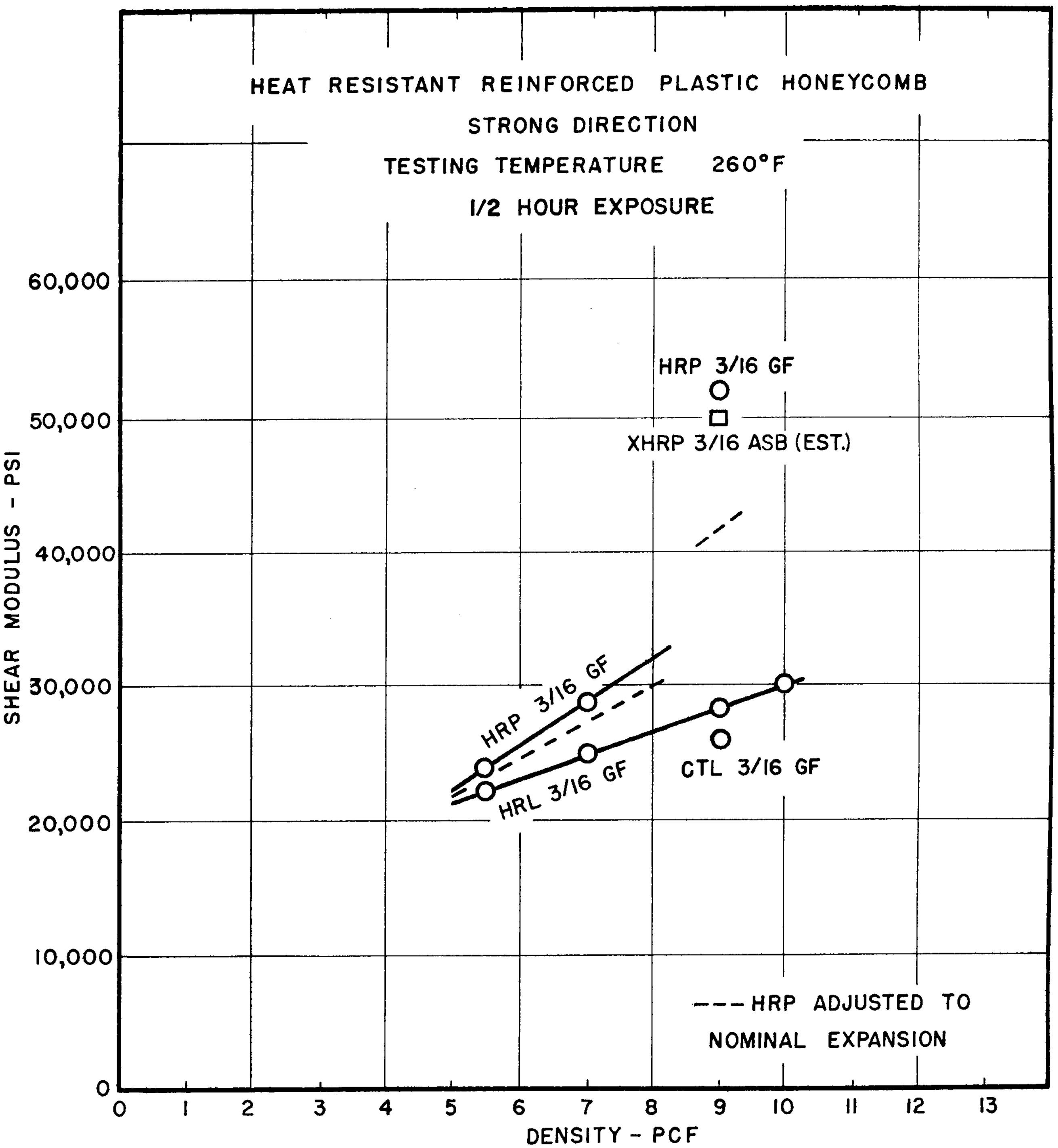

HEAT RESISTANT REINFORCED PLASTIC HONEYCOMB
STRONG DIRECTION
TESTING TEMPERATURE 260°F
1/2 HOUR EXPOSURE
HRP 3/16 GF
XHRP 3/16 ASB (EST.)
HRP 3/16 GF
HRL 3/16 GF
CTL 3/16 GF
---HRP ADJUSTED TO NOMINAL EXPANSION
SHEAR MODULUS - PSI
60,000
50,000
40,000
30,000
20,000
10,000
0
0
1
2
3
4
5
6
7
8
9
10
11
12
13
DENSITY - PCF

FIG. 9

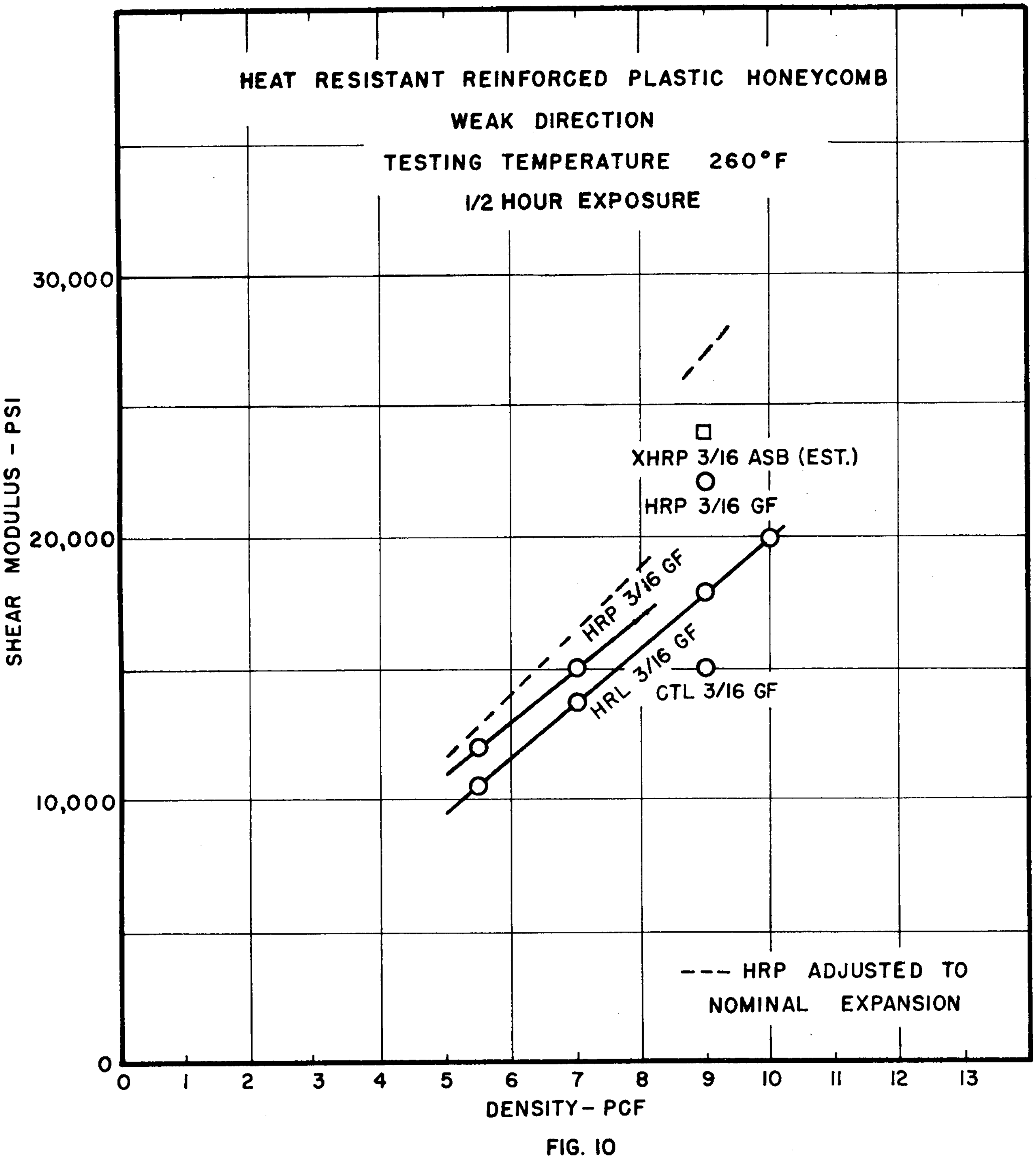
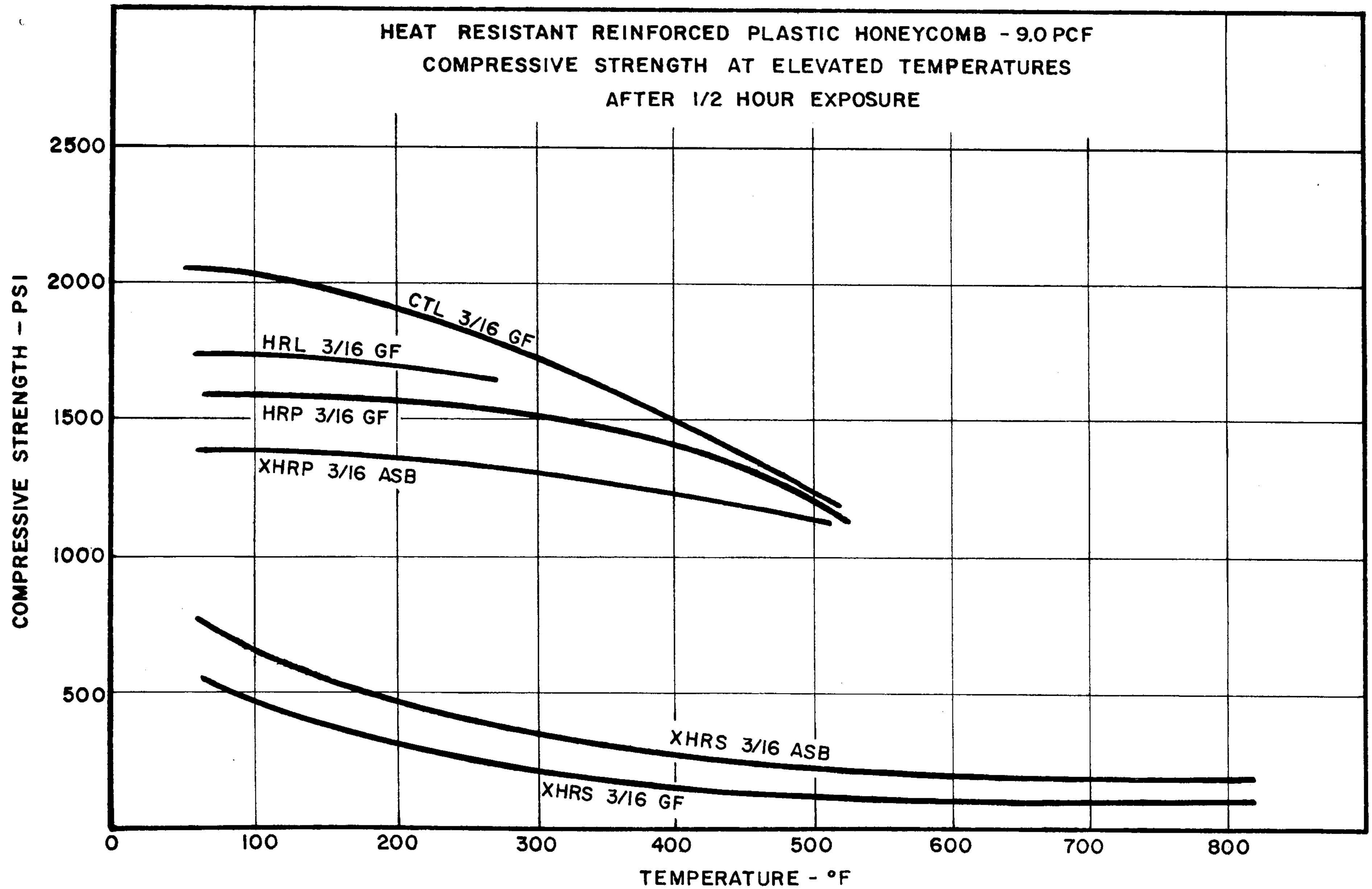

HEAT RESISTANT REINFORCED PLASTIC HONEYCOMB
WEAK DIRECTION
TESTING TEMPERATURE 260°F
1/2 HOUR EXPOSURE
SHEAR MODULUS - PSI
30,000
20,000
10,000
0
XHRP 3/16 ASB (EST.)
HRP 3/16 GF
HRP 3/16 GF
HRL 3/16 GF
CTL 3/16 GF
--- HRP ADJUSTED TO NOMINAL EXPANSION
0
1
2
3
4
5
6
7
8
9
10
11
12
13
DENSITY - PCF

FIG. 10



HEAT RESISTANT REINFORCED PLASTIC HONEYCOMB - 9.0 PCF
COMPRESSIVE STRENGTH AT ELEVATED TEMPERATURES
AFTER 1/2 HOUR EXPOSURE
CTL 3/16 GF
HRL 3/16 GF
HRP 3/16 GF
XHRP 3/16 ASB
XHRS 3/16 ASB
XHRS 3/16 GF
2500
2000
1500
1000
500
COMPRESSIVE STRENGTH - PSI
0
100
200
300
400
500
600
700
800
TEMPERATURE - °F

FIG. 11

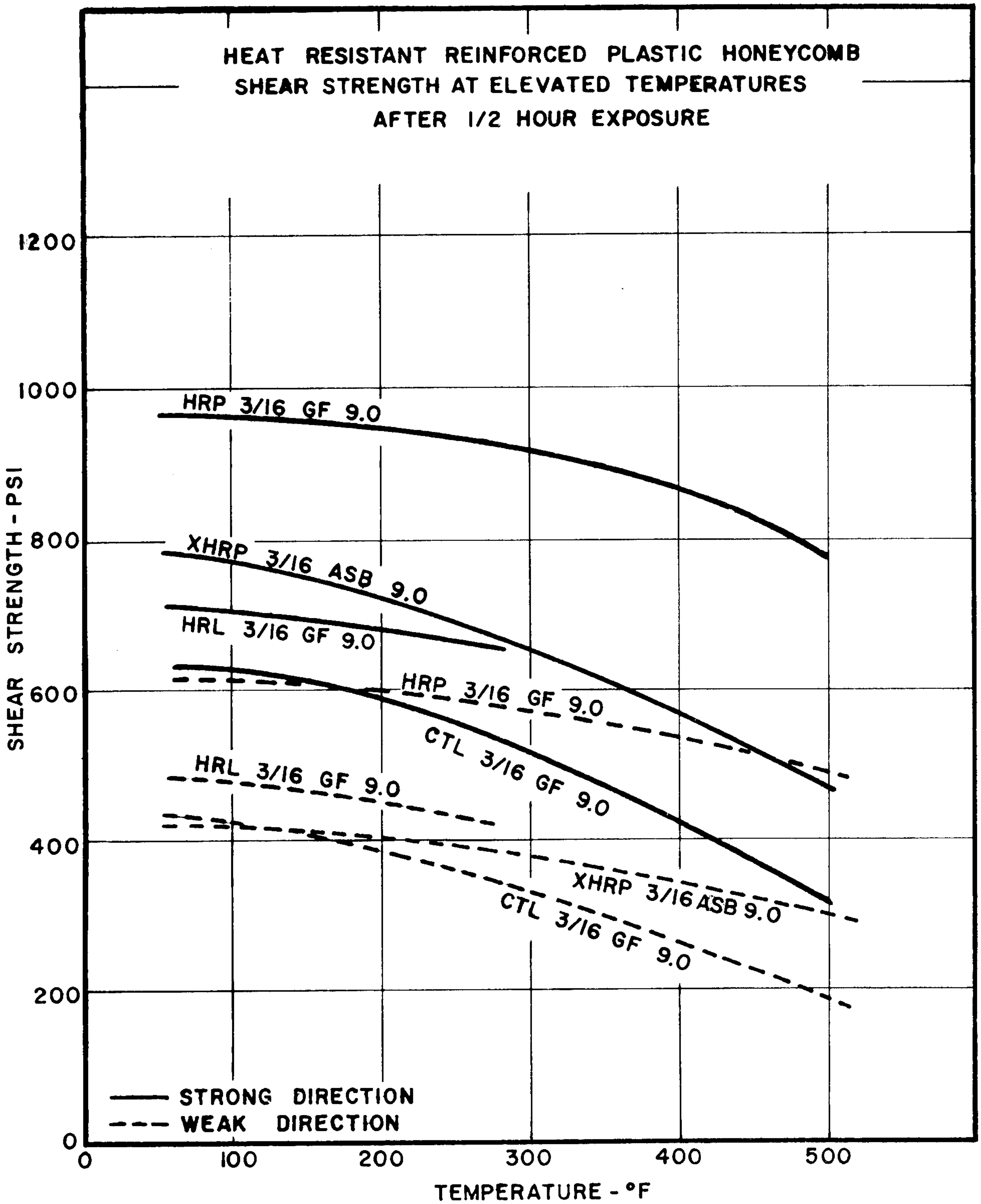
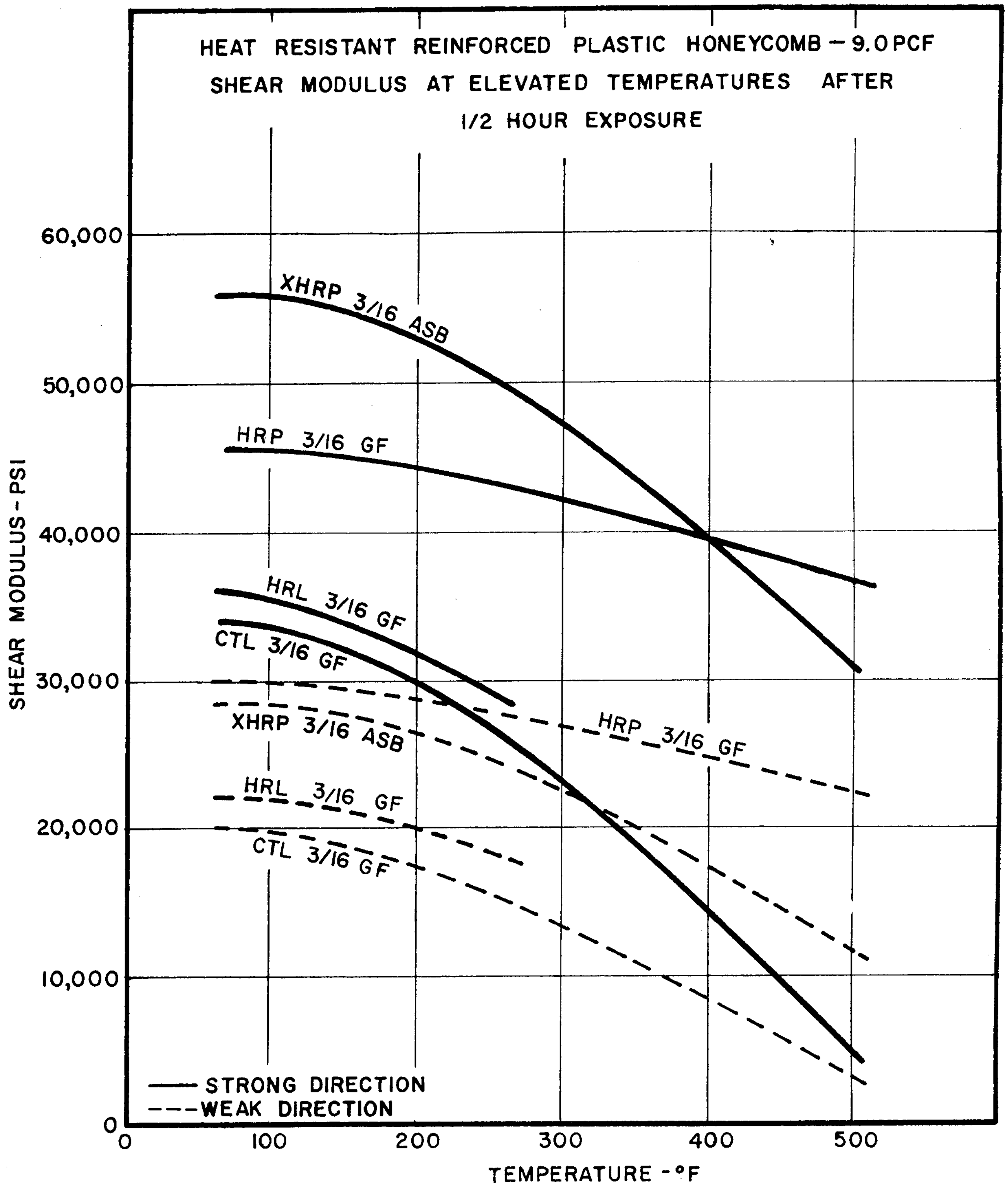

HEAT RESISTANT REINFORCED PLASTIC HONEYCOMB
SHEAR STRENGTH AT ELEVATED TEMPERATURES
AFTER 1/2 HOUR EXPOSURE
HRP 3/16 GF 9.0
XHRP 3/16 ASB 9.0
HRL 3/16 GF 9.0
HRP 3/16 GF 9.0
CTL 3/16 GF 9.0
HRL 3/16 GF 9.0
XHRP 3/16 ASB 9.0
CTL 3/16 GF 9.0
STRONG DIRECTION
WEAK DIRECTION
SHEAR STRENGTH - PSI
1200
1000
800
600
400
200
0
0
100
200
300
400
500
TEMPERATURE - °F

FIG. 12



HEAT RESISTANT REINFORCED PLASTIC HONEYCOMB — 9.0 PCF
SHEAR MODULUS AT ELEVATED TEMPERATURES AFTER
1/2 HOUR EXPOSURE
XHRP 3/16 ASB
HRP 3/16 GF
HRL 3/16 GF
CTL 3/16 GF
XHRP 3/16 ASB
HRP 3/16 GF
HRL 3/16 GF
CTL 3/16 GF
STRONG DIRECTION
WEAK DIRECTION
SHEAR MODULUS - PSI
60,000
50,000
40,000
30,000
20,000
10,000
0
0
100
200
300
400
500
TEMPERATURE - °F

FIG. 13

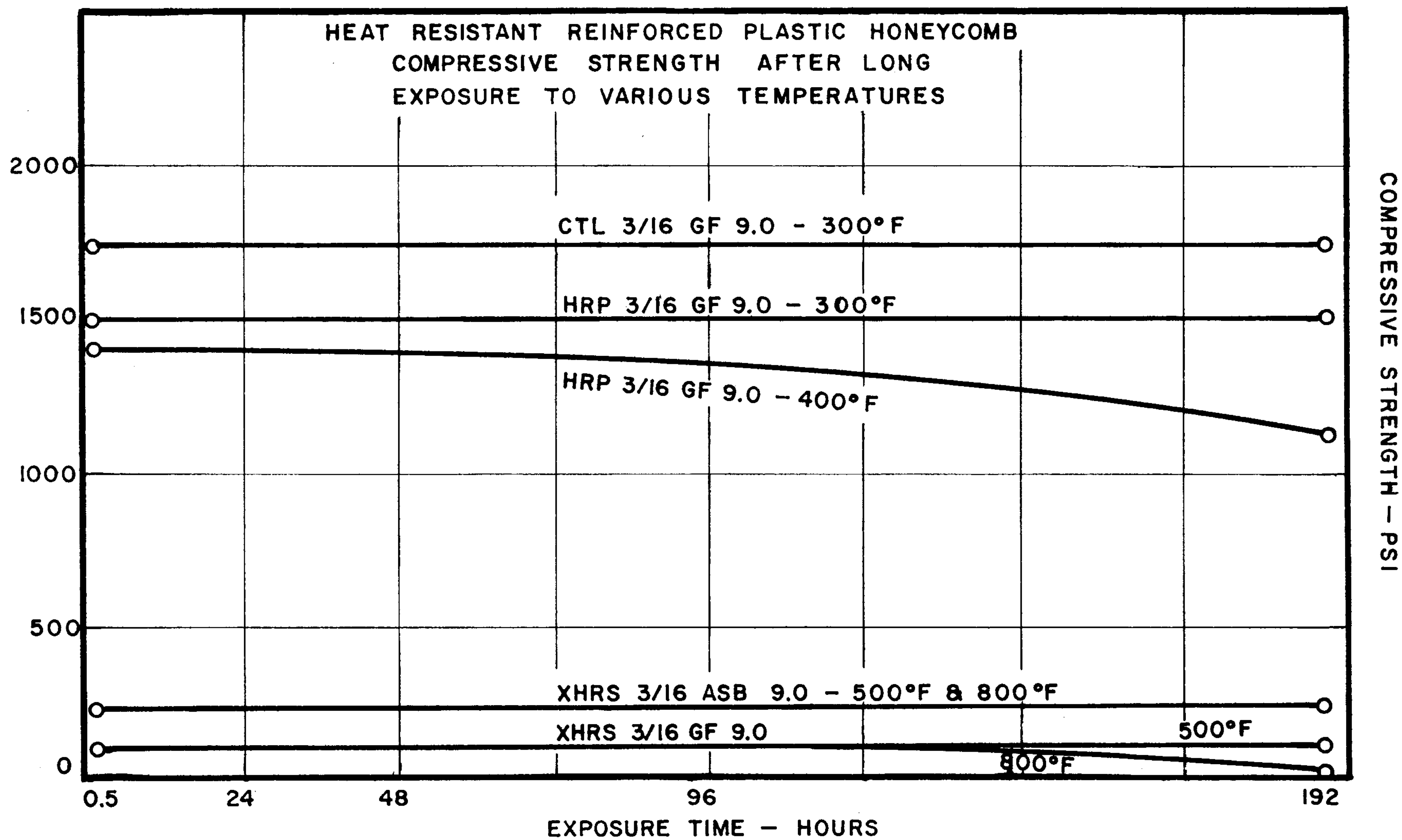

HEAT RESISTANT REINFORCED PLASTIC HONEYCOMB
COMPRESSIVE STRENGTH AFTER LONG
EXPOSURE TO VARIOUS TEMPERATURES
CTL 3/16 GF 9.0 - 300°F
HRP 3/16 GF 9.0 - 300°F
HRP 3/16 GF 9.0 - 400°F
XHRS 3/16 ASB 9.0 - 500°F & 800°F
XHRS 3/16 GF 9.0
500°F
800°F
2000
1500
1000
500
0
0.5
24
48
96
192
EXPOSURE TIME - HOURS
COMPRESSIVE STRENGTH - PSI

FIG. 14